

WHAT IS CLAIMED IS:

1. A shaft, comprising:
 - an annular mid shaft having first and second ends, said mid shaft comprising a metal matrix composite material;
 - an annular first transition piece having first and second end layers and a barrier layer disposed between said first and second end layers, said first transition piece being disposed coaxially with said mid shaft, wherein said first end layer comprises a first alloy and said second end layer comprises a second alloy and abuts said first end of said mid shaft at a first welded joint, wherein said barrier layer comprises an alloy effective for preventing the formation of intermetallic compounds between said first alloy and said second alloy;
 - an annular first end shaft disposed coaxially with said mid shaft and said first transition piece, said first end shaft having an end abutting said first end layer of said first transition piece at a second welded joint, wherein said first end shaft comprises said first alloy.
2. The shaft of claim 1 wherein said mid shaft comprises said second alloy.
3. The shaft of claim 1 further comprising an annular second end shaft disposed coaxially with said mid shaft, said first transition piece, and said first end shaft, said second end shaft having an end abutting said second end of said mid shaft at a third welded joint, wherein said second end shaft comprises said second alloy.
4. The shaft of claim 1 further comprising:
 - an annular second transition piece having first and second end layers and a barrier layer disposed between said first and second end layers, said second transition piece being disposed coaxially with said mid shaft, wherein said first end layer comprises said first alloy and said second end layer comprises said second alloy and abuts said second end of said mid shaft at a third welded joint, wherein said barrier layer comprises an alloy effective for preventing the formation of intermetallic compounds between said first alloy and said second alloy;

an annular second end shaft disposed coaxially with said mid shaft and said second transition piece, said second end shaft having an end abutting said first end layer of said second transition piece at a fourth welded joint, wherein said second end shaft comprises said first alloy.

5. A shaft, comprising:

an annular mid shaft having first and second ends, said mid shaft comprising a metal matrix composite material;

an annular first transition piece having first and second end layers and a barrier layer disposed between said first and second end layers, said second transition piece being disposed coaxially with said mid shaft, wherein said first end layer comprises a nickel-based alloy, said barrier layer comprises a niobium-based alloy, and said second end layer comprises a titanium-based alloy and abuts said first end of said mid shaft at a first welded joint;

an annular first end shaft disposed coaxially with said mid shaft and said first transition piece, said first end shaft having an end abutting said first end layer of said first transition piece at a second welded joint, wherein said first end shaft comprises a nickel-based alloy.

6. The shaft of claim 5 wherein said mid shaft comprises a titanium-based alloy.

7. The shaft of claim 5 further comprising an annular second end shaft disposed coaxially with said mid shaft, said first transition piece, and said first end shaft, said second end shaft having an end abutting said second end of said mid shaft at a third welded joint, wherein said second end shaft comprises a titanium-based alloy.

8. The shaft of claim 5 further comprising:

an annular second transition piece having first and second end layers and a barrier layer disposed between said first and second end layers, said second transition piece being disposed coaxially with said mid shaft, wherein said first end layer comprises a nickel-based alloy, said barrier layer comprises a niobium-based alloy, and said second end layer comprises a

titanium-based alloy and abuts said second end of said mid shaft at a third welded joint;

an annular second end shaft disposed coaxially with said mid shaft and said second transition piece, said second end shaft having an end abutting said first end layer of said second transition piece at a fourth welded joint, wherein said second end shaft comprises a nickel-based alloy.

9. A method of assembling a shaft, comprising:

providing an annular first end shaft comprising a first alloy;

providing an annular first transition piece, said first transition piece having a first end layer comprising said first alloy, a second end layer comprising a second alloy, and a barrier layer disposed between said first end layer and said second end layer;

inertia friction welding said first end shaft to said first end layer of said first transition piece to form a first subassembly;

heat treating said first subassembly;

providing an annular mid shaft having first and second ends, said mid shaft made from a metal matrix composite material comprising said second alloy; and

inertia friction welding said first end of said mid shaft to said second end layer of said first transition piece.

10. The method of assembling a shaft of claim 9 further comprising:

providing an annular second end shaft comprising said second alloy;

and

inertia friction welding said second shaft to said forward end of said mid shaft.

11. The method of assembling a shaft of claim 9 further comprising:

providing an annular second end shaft comprising said first alloy;

providing an annular second transition piece, said second transition piece having a first end layer comprising said first alloy, a second end layer comprising said second alloy, and a barrier layer disposed between said first end layer and said second end layer;

inertia friction welding said second end shaft to said first end layer of said second transition piece to form a second subassembly;

heat treating said second subassembly; and
inertia friction welding said second subassembly to said second end of
said mid shaft.

12. The method of assembling a shaft of claim 9 wherein said first alloy is a nickel-based alloy.

13. The method of assembling a shaft of claim 9 wherein said second alloy is a titanium-based alloy.

14. The method of assembling a shaft of claim 9 wherein said first transition piece includes a central web having at least one slot formed therethrough, and wherein said step of inertia friction welding said first end shaft to said first end layer of said first transition piece includes restraining said first transition piece from rotation using at least one key, said key being disposed in said slot and attached to a tailstock of an inertia friction welding machine.

15. The method of assembling a shaft of claim 11 wherein said second transition piece includes a central web having at least one slot formed therethrough, and wherein said step of inertia friction welding said second end shaft to said first end layer of said second transition piece includes restraining said second transition piece from rotation using at least one key, said key being disposed in said slot and attached to a tailstock of an inertia friction welding machine.